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Characterizing Jupiter's energetic (>15 MeV) particle environment with the Juno MAG investigation's micro Advanced Stellar Compass

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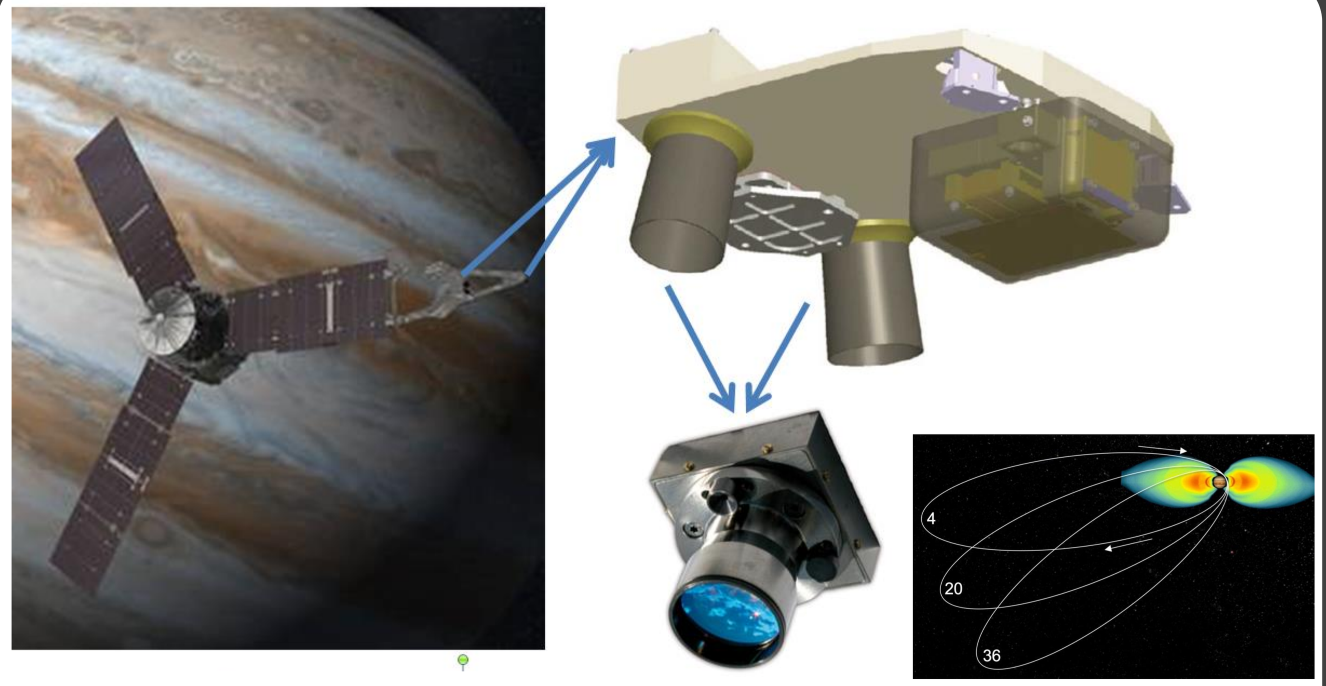


Credit: NASA/GSFC/JPL-Caltech/DTU Space

NASAs Juno mission entered into polar orbit about Jupiter on July 4th, 2016. Since then 17 science orbits have been completed, systematically mapping the 3D magnetosphere of Jupiter for the first time. Located on the tip one of Juno's three solar arrays, the Magnetic Field Experiment carries an absolute attitude reference sensor, the fully autonomous "micro Advances Stellar Compass" (µASC) designed and built at the Technical University of Denmark.

micro Advanced Stellar Compass µASC

- Designed and produced by the Measurement and Instrumentation Systems (DTU Space)
- One of the most successful star tracker worldwide
- Autonomously calculates attitude based on all bright stars in the CHUs Field of View
- Absolute accuracy of < 1 arc second
- Operating on many satellite missions without a single hardware or functional failure

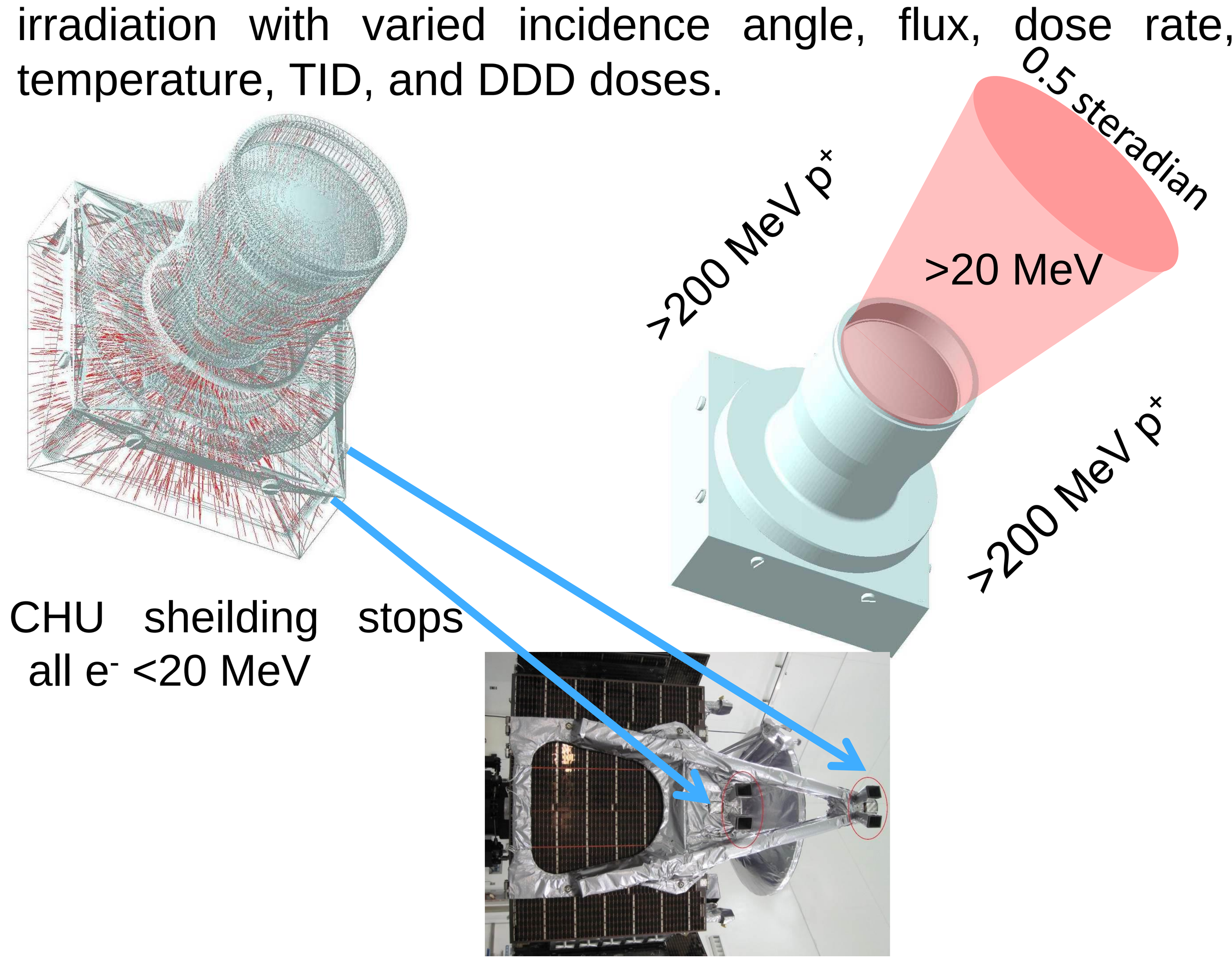
µASC's Advanced Observational Capabilities:

- Optical imaging of solar system bodies
- Autonomous detection and tracking of objects
- Characterization of the hypervelocity dust impacts on the spacecraft.
- Detecting high energy particles (>15MeV electrons and 100MeV protons)

The µASC provides continuous record of the energetic particle environment traversed by Juno, and its interaction with the moons of Jupiter. We give an overview of the highly energetic particle population, the interaction with the Jovian moons, and the footprints left in the Jovian atmosphere by the Galilean satellites.

Calibration

The µASC response to the high energy irradiation is fully calibrated using 1-2 MeV electron and 30-200 MeV proton irradiation with varied incidence angle, flux, dose rate, temperature, TID, and DDD doses.



Calibrating images acquired during irradiation with high flux of electrons (left) and heavies (right).

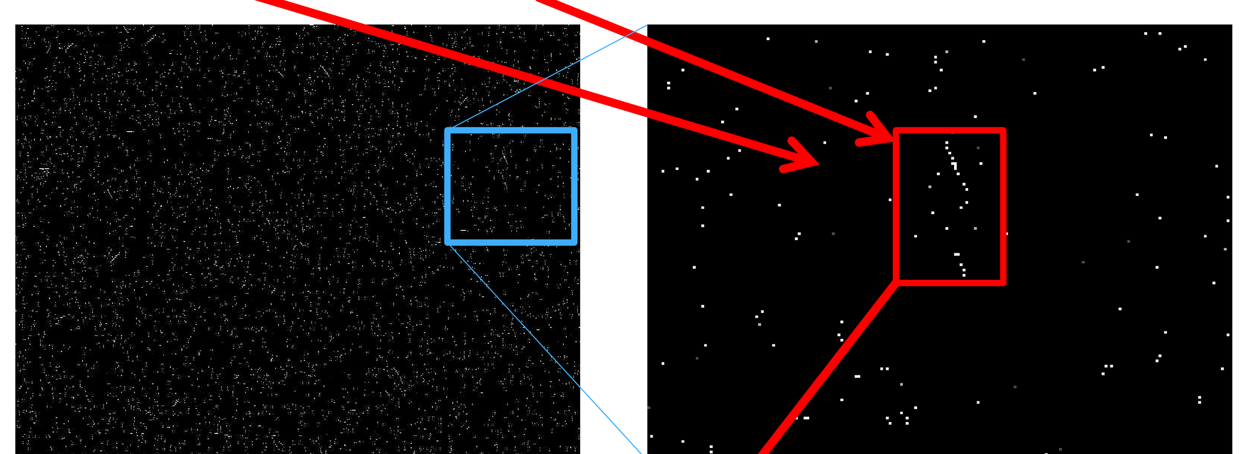
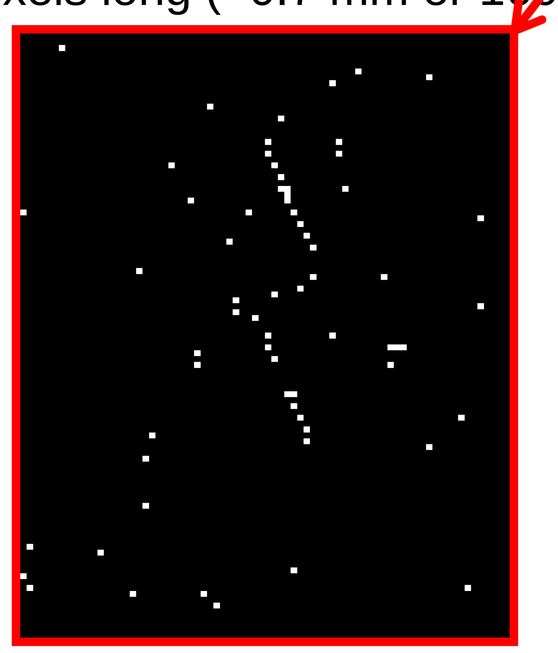


Image analysis. Deposited energy

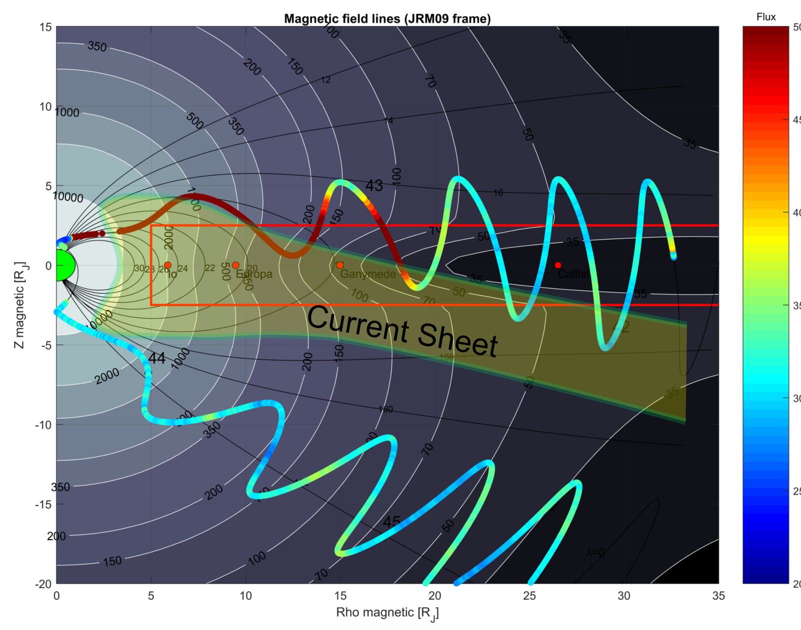
A track left by an energetic particle that hit the CCD is ~50 pixels long (~0.7 mm or 160 mg/cm²) and has 4 or 5 splits due to recoil nuclei produced by the incident particle in silicon. Estimation of the primary energy of a particle that could traverse at least 0.7 mm in Si behind the heavy shielding will involve the transport flux modelling for the µASC, the calibration curves of the CCD and inflight image analysis.



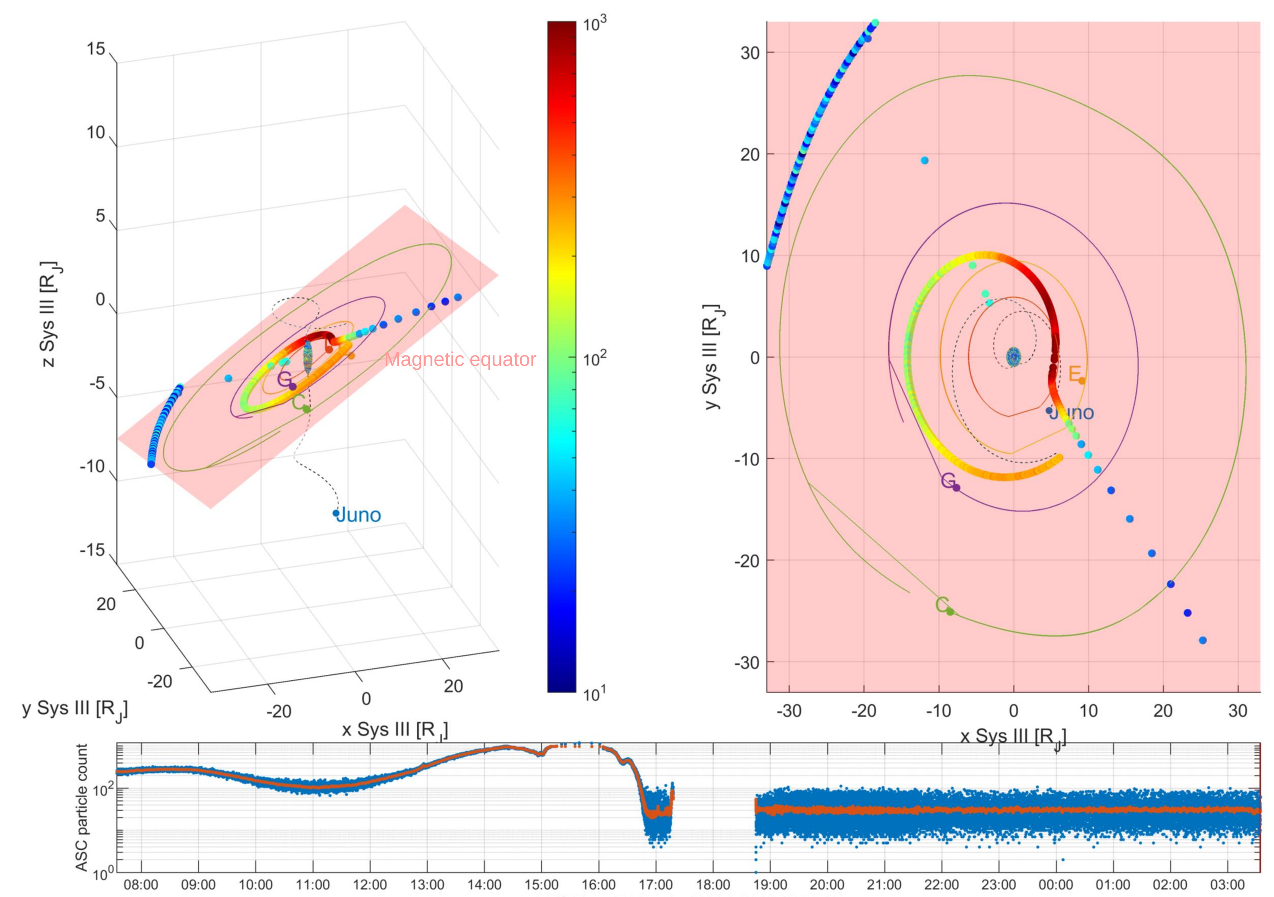
Heavy particle with incoming E>> 85MeV

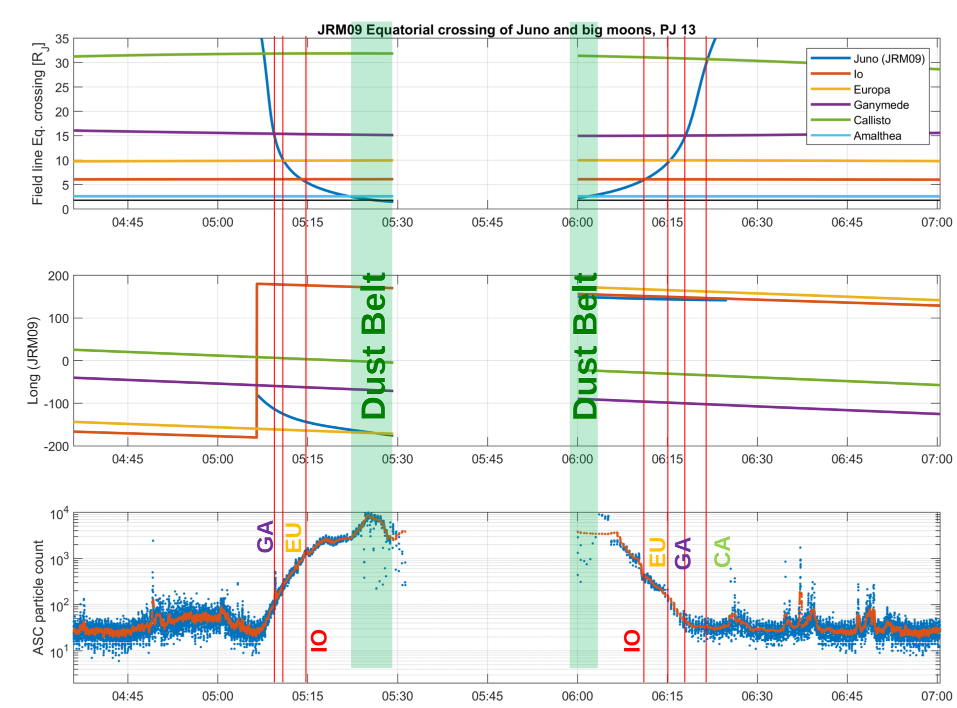
Observations

The wiggle plot below shows Juno's position in magnetic coordinates (Rho, Z) in [R_J]. In the trace of the orbit, the flux measured by the µASC is displayed with a color scale. The major Jovian moons radial distance have been also added in the plot in addition to the model of the magnetodisc.

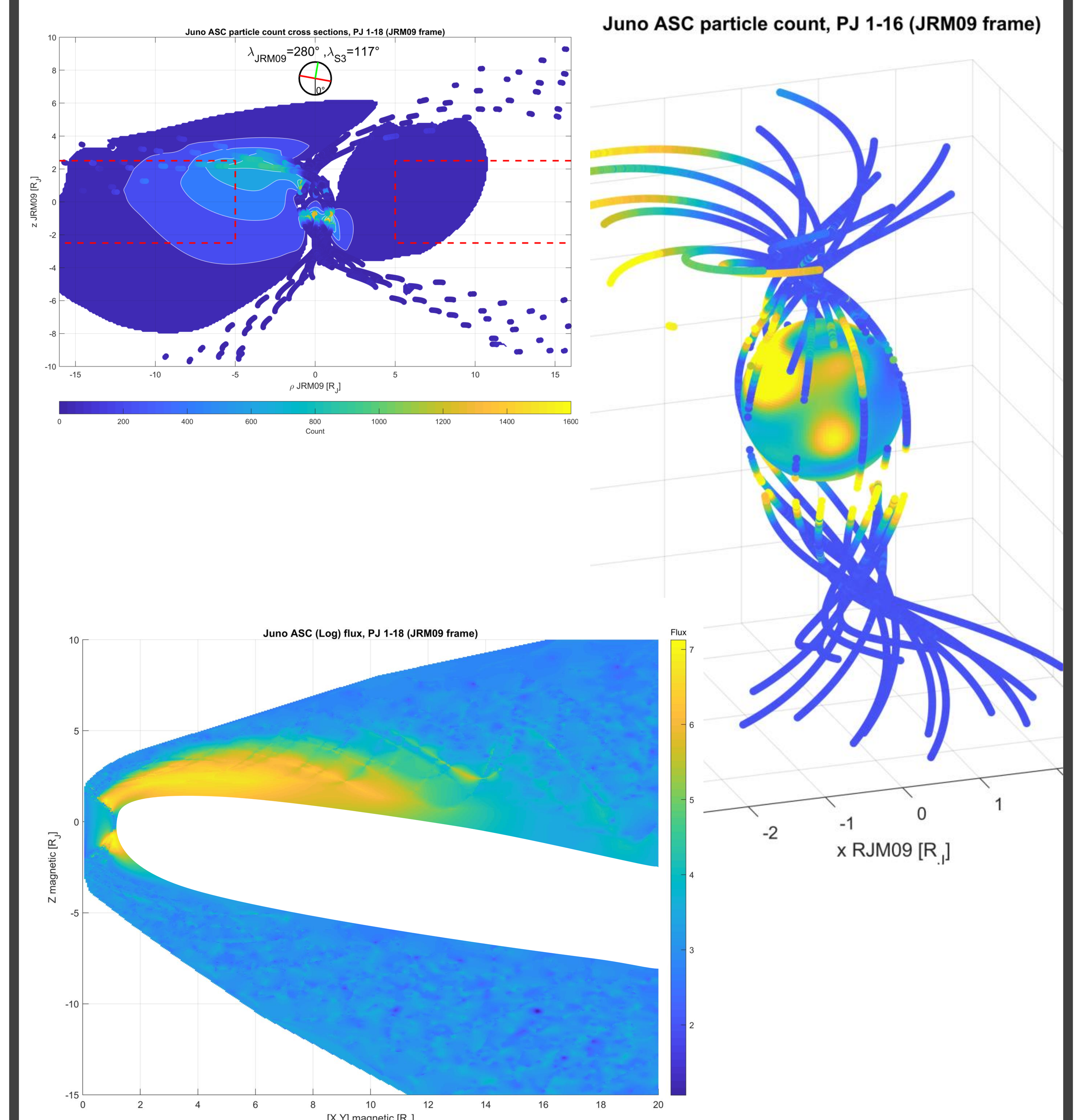


Juno's crossing of the magnetic field lines which intersect the Jovian moon orbits is shown. These crossings are correlated with observations of the µASC particle counter.



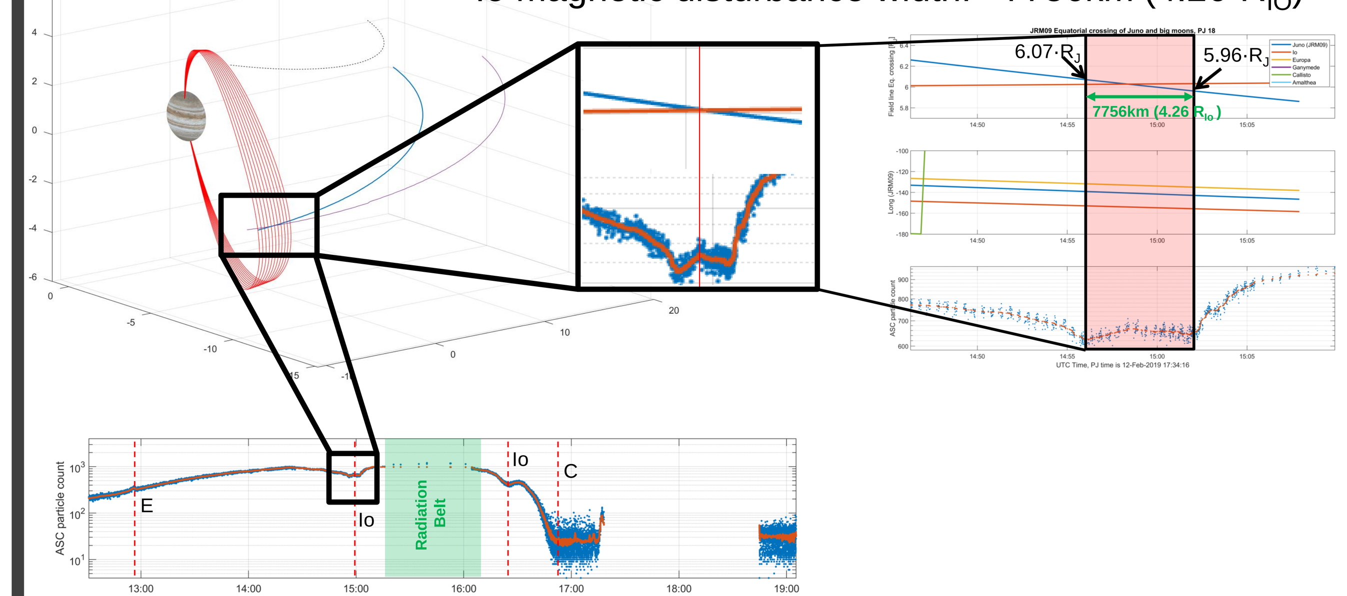


Jupiter's particle environment



Io diameter: 3642km (2·R_{IO})

Io magnetic disturbance width: ~7756km (4.26·R_{IO})



Highlights

- Model of the Jupiter's high energy radiation environment
- Better constrains on the Jupiter's current sheet
- Magnetic footprint of the Jupiter's inner planet

Ref.: Connerney, J.E.P., Benn, M., Bjarno, J.B. et al. Space Sci Rev (2017) 213: 39. https://doi.org/10.1007/s11214-017-0334-z